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Characterization and evaluation of soil resources of patapur microwatershed for sustainable land use planning

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Abstract: Soils of Patapur micro-watershed area. Manvi taluk, Raichur district, Karnataka, were studied for their properties and evaluation. Land capability subclasses in the study area were III and IV with limitations of texture, drainage, fertility and topography. Majority of the crops were moderately to marginally suitable and few were currently and potentially unsuitable.

Key words: Land, Morphological, Physical, Chemical properties, Texture, Drainage, Fertility and Topography

Introduction

Land available per capita in India has been declining significantly from 0.48 ha in 1951 to 0.20 ha in 1981 and to 0.15 ha in 2000 (Singh, 1999) and is likely to become 0.10 ha by 2025 (Kanwar, 1999). To meet the demand for food grains to feed more than one billion people, vigorous exploitation of natural resources such as land and water will be done which poses serious threat to the sustainability of environment. Since soils in general are degrading due to poor management and faulty land use at a rate faster than their natural degeneration, it becomes imperative to protect them from further degradation; as there is a concomitant decline in soil quality to produce healthy crops. Detailed soil survey was undertaken to characterize and evaluate soils of Patapur micro-watershed, Manvi taluk of Raichur district, covers an area of 200 ha. It comprises of both red and black soils differing in their morphological, physical, chemical and mineralogical characteristics. Their characterization and evaluation is crucial for productive and sustainable management of soils. Knowledge about chemical and physical properties of soils helps in better crop planning. For the sustainable use of the natural resources, a detailed characteristic of land resources giving its potential and constraints becomes pre-requisite for planning. The site specificity of agricultural research and technology is largely measured from differences in two environmental variables, soil and climate. Hence the study was undertaken.

Materials and Methods

Study was undertaken during 2011-12 in North Eastern dry zone. The micro-watershed was delineated using Survey of India toposheet (56 D/16) covered the villages of Guddinne, Chikkanige and Patapur. Manvi taluk Raichur district, Karnataka. It is located between 16^0 07' 35.9'' N and 16^0 08' 22.3'' N latitudes and 76^0 51' 33.3''E and 76^0 53' 27.7'' E longitudes with an average elevation of 447 m above Mean Sea Level (MSL). Total area of the microwatershed is 200 ha as per cadastral data. Climate of area is semiarid and mean annual rainfall is 628 mm (30 years average). Mean annual temperature of area is 33.9 °C.

Soil Survey: Soil survey was carried out for micro-watershed using toposheet (56 D/16) which used to prepare base maps covering the villages of Guddinne, Chikkanige and Patapur. This micro-watershed is henceforth called in this thesis as "Patapur micro-watershed". A tracing film was overlaid on the toposheet covering the study area. Boundary of the watershed and important land features like contours, streams, watershed boundary, villages and roads etc., were extracted. This map having the above land feature was used as a base map for preparing soil and interpretation maps. Base map is shown in Fig.2. Google earth image of the micro-watershed is used for general view of lands and soils for traversing land classification and selection of pedons for soil study. Google earth image is represented in (Fig. 1).

Land capability classification: The land capability was mainly based on the inherent soil characteristics, external land features and environmental factors. The land capability classes and sub classes were arrived at as per the guidelines in Soil Survey Manual (AISLUS, 1971). The criteria used for land capability classification are presented in (table-1). Based on soil properties, the soils of Patapur micro-watershed of Manvi taluk have been classified into two land capability classes viz., III and IV (Table 1). The upland and lowland were grouped under land capability sub-class IVe and IVs, respectively. These soils were marginally cultivable lands due to severe limitations of erosion limitations. Whereas, midland was classified into two classes III and IV, which are marginally cultivable lands with severe limitations of coarse fragments, moderate drainage, soil characteristic and fertility factor limitations.\

Soil-site suitability for crops: The classification is based on the FAO (1993b), framework for land evaluation. The classification includes four categories: orders, classes, sub classes and units. There are two orders (S, N), which reflect the kind of suitability (S for suitable and N for not suitable). There are three classes (S_1, S_2 and S_3) under the order S and two classes (N_1 and N_2) under the order N, reflecting degree of suitability within the order. The appraisal

of the classes, within an order is done according to evaluation of land limitations. The sub classes reflect the kinds of limitations or the main kinds of improvement measures required within a class. They are indicated by the symbol, using lower case letters following the arabic numeral used for the class. The land suitability unit suggests the relative importance of land improvement works. It is indicated by arabic numerals enclosed in parenthesis following the sub class symbol. Soil site suitability for some of the major crops like maize, sorghum, pearl millet, groundnut, sunflower, pigeon pea and cotton were evaluated based on the criteria suggested by Sehgal (1996).

The earlier system of evaluation grades the land from suitable to unsuitable, irrespective of type of land use and management. Such a system cannot provide the necessary information to the land users so as to make a choice between land use options. The FAO framework for land evaluation was used in the present study to know the consequences of applying the specified management to a particular piece of land so that a choice could be made from the alternatives. This method, asseses the suitability of lands of micro-watershed for major crops such as cotton, sorghum, redgram, pearlmillet, sunflower maize and groundnut on the basis of matching exercise between the growth and production requirements of the crops and socio-economic condition of the land users was made. Based on number and degree of limitations in the present study, the suitability classes *viz.,* highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N) classes were adopted to evaluate the soils.

Land evaluation: Land evaluation was carried out based on soil-site characteristics which are mentioned in (Table-1 and 2)

Land capability classification: The land capability was mainly based on the inherent soil characteristics, external land features and environmental factors. The land capability classes and sub classes were arrived at as per the guidelines in Soil Survey Manual (AISLUS, 1971). The criteria used for land capability classification are presented in Table-1.

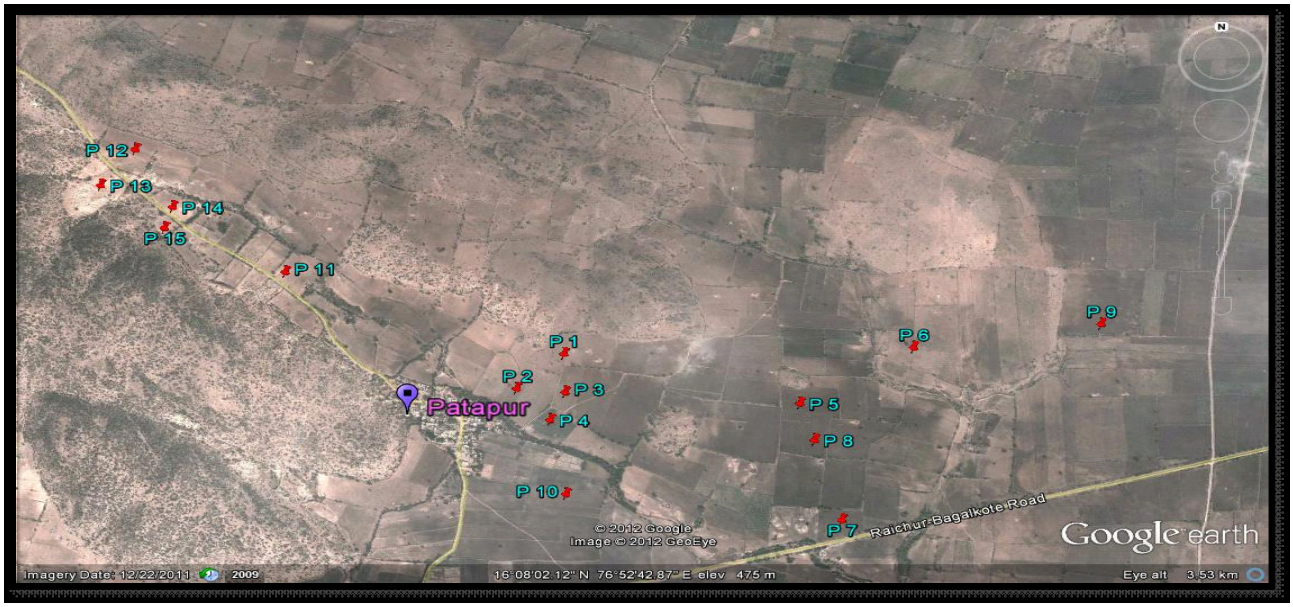

Fig. 1: Google earth map in patapur microwatershed area

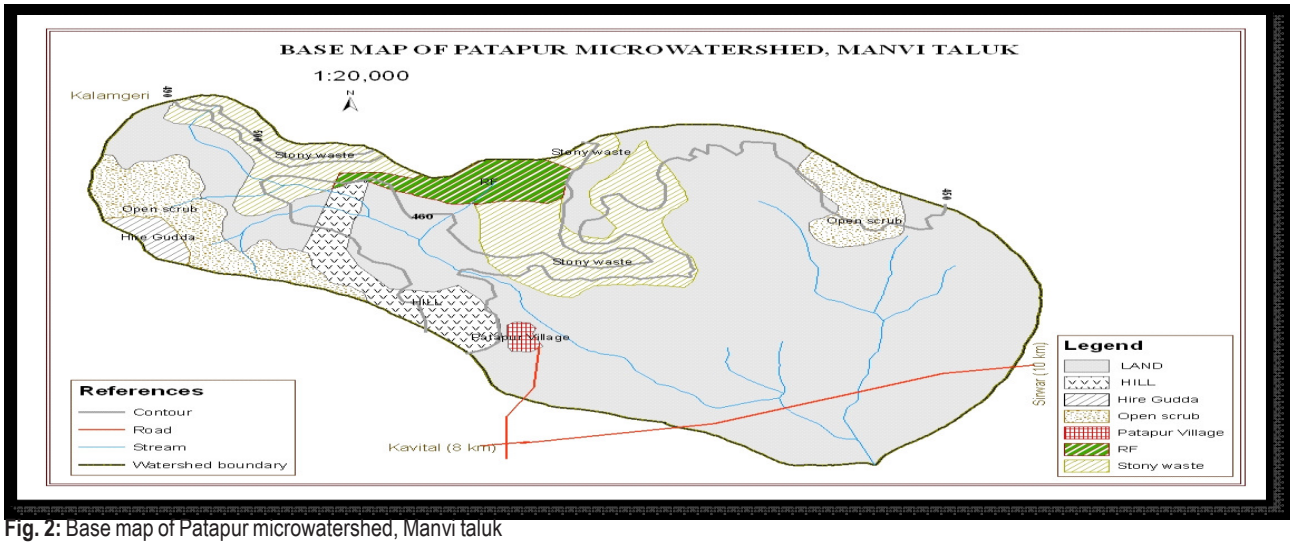

Fig. 2: Base map of Patapur microwatershed, Manvi taluk

Table -1: Land capability classification – quantification of the criteria

Characteristics	Class-I	Class-II	Class-III	Class-IV	Class-V	Class-VI	Class-VII	Class- VIII
Topography (t)								
Slope (%)	0-1	3-Jan	8-Mar	15-Aug	Upto 3	15-35	35-50	>50
Erosion	Nil	Slight	Moderate	Severe	Nil	Severe	Severe	-
Wetness (w)								
Flooding	Nil (F0)	Nil(F0) (F0/F1)	Nil to slight (F1/F2)	Slight to mod. (F3)	Mod. to severe (F0/F3)	Nil to severe (F0/F4)	Nil to very	-
Drainage (I)	Well	Mod. well	Imperfect	Poor	V. poor	Excessive	Excessive	Excessive
Permeability	Moderate	Mod. rapid	Raid slow	v. rapid, v. slow	-	-	-	-
Infiltration rate (cm/hr)	2-3.5	1-2, 3-5	0.5-1, 5-10	<0.5, >10.0	2	-	-	-
Physical characteristics								
Surface texture	Loam	sil & cl	sl & c	scl	s, c(m)	ls-cl	ls, s, c	ls, s, c(m)
Surface coarse fragments (vol %)	3-Jan	15-Mar	15-40	40-75	15-75	75+	-	-
Surface stoniness (%)	<1	3-Jan	5-Mar	8-May	15-Aug	15-40	40-75	>75
Subsurface coarse fragments (%)	<15	<15	15-35	35-50	50-75	50-75	50-75	>75
Soil depth (cm)	>150	150-100	100-50	50-25	-	25-10	25-10	<10
Profile development	Cambic /Argillic hor. A-(B)-C	A-B-C	Stratified A-C; A-B-C	Salic(Z)/ Calcic (K) hor. A-Bz-C/A-Bk-C	Az-C, A-B, C	Gypsic (y) hor. A-cy	A-C (stony)	A-C (bouldary)
Fertility (f)								
CEC (cmol (p+)/kg)	40-16	16-12	16-12	-	-	-	-	-
Base saturation (%)	80+	80+	80-50	50-35	50-35	35-15	<15	-
OC (0-15 cm) (%)	>10	0.75-1.0	0.5-0.75	<0.5	<0.5	-	-	-
Salinity EC(dS/m)	<10	2-Jan	4-Feb	8-Apr	15-Aug	15-35	35-50	>50
Gypsum	0.3-2.0	5-Feb	10-May	15-Oct	15-25	>25	-	-

Table-2: Soil-site characteristics of micro-watershed for land evaluation

Pedon	Climate (c)				Land form characteristics				Physico-chemical characteristics (f)						
No.	Rain fall (mm)	Max. temp. (^{0}C)	Min temp. (^{0}C)	RH (%)	Slope (%) (t)	Erosion (e)	Drainage (w)	Depth (cm)	$CaCO_3$ (%)	Texture	pH	OC (%)	CEC (cmol (p+)/kg)	Base Saturation (%)	ESP (%)
Upland															
Pedon.1	628	33.9	21.1	71.6	8-Mar	Moderate	Well drained	68	0	scl	7.3	0.74	13	90.57	2.51
Midland															
Pedon.2	628	33.9	21.1	71.6	0-1	V. Slow	Imperfect	150+	7	cl	8.17	0.65	35.89	87.69	3.73
Pedon.3	628	33.9	21.1	71.6	0-1	V. Slow	Mod. well	127	8.5	c	9.11	0.86	43.97	92.49	8.24
Pedon.4	628	33.9	21.1	71.6	0-1	V. Slow	Imperfect	100	5	c	8.37	0.6	37.44	88.69	2.48
Pedon.5	628	33.9	21.1	71.6	0-1	Severe	Imperfect	108+	13.8	c	8.41	1.14	38.95	87.1	6.36
Pedon.6	628	33.9	21.1	71.6	0-1	Severe	Imperfect	71+	12.5	c	7.94	0.48	36.62	89.66	6.58
Lowland															
Pedon.7	628	33.9	21.1	71.6	0-1	Severe	Imperfect	85+	20.2	c	8.94	1.35	37.82	93.14	9.58

Table-3: Land capability classification of Patapur micro-watershed

Pedon	Land form characteristics			Physical characteristics (s)			Chemical characteristics (f)			LCC
	Slope (%)	Erosion (t)	Drainage (e)	Texture (w)	Soil depth	Pedon development	CEC (cmol (p+) kg^{-1})	OC (%)	Base Saturation (%)	
Upland										
Pedon.1	III	III	I	IV	III	II	II	III	I	IVs
Midland										
Pedon.2	I	II	III	II	I	I	I	III	I	IIIwf
Pedon.3	I	II	II	III	II	I	I	II	I	IIIs
Pedon.4	I	II	III	III	III	II	I	III	I	IIIwsf
Pedon.5	I	IV	III	III	II	I	I	II	I	IVe
Pedon.6	I	IV	III	III	III	II	I	IV	I	IVef
Lowland										
Pedon.7	I	IV	III	III	III	II	I	I	I	IVe

Results and Discussion

Soil-site suitability evaluation for crops: The classification is based on the FAO (1993b), framework for land evaluation. The classification includes four categories: orders, classes, sub classes and units. There are two orders (S, N), which reflect the kind of suitability (S for suitable and N for not suitable). There are three classes (S_1, S_2 and S_3) under the order S and two classes (N_1 and N_2) under the order N, reflecting degree of suitability within the order. The appraisal of the classes, within an order is done according to evaluation of land limitations. The sub classes reflect the kinds of limitations or the main kinds of improvement measures required within a class. They are indicated by the symbol, using lower case letters following the arabic numeral used for the class. The land suitability unit suggests the relative importance of land improvement works. It is indicated by arabic numerals enclosed in parenthesis following the sub class symbol. Soil site suitability for some of the major crops like maize, sorghum, pearl millet, groundnut, sunflower, pigeon pea and cotton were evaluated based on the criteria suggested by Sehgal (1996).

Cotton: A soil depth of 50-200 cm, 5 to 20 per cent $CaCO_3$, moisture storage capacity of 220 mm and base saturation of more than 80 percent optimum for cotton. The study area represented by upland was marginally suitable for cotton. Because of severe limitations of erosion, midland pedons (pedons 2 and 4) were moderately suitable due to moderate limitations of drainage, organic carbon content. Whereas the other midland pedons (pedons 3, 5 and 6) were also marginally suitable owing to their more number (>3) of severe limitations of erosion, $CaCO_3$ content. Similarly, lowland was marginally suitable for cotton because of severe limitations of erosion, $CaCO_3$ content. The crucial limit for available moisture content has been observed to be 100 mm below which yields are uneconomic (Sehgal, 1991).

Sorghum: The factors that influencing sorghum yield are rainfall, temperature, slope, BS, $CaCO_3$, CEC and texture. The area represented by upland was moderately suitable, because of moderate limitations of slope, erosion and rainfall and the midland (pedon 2 and 4) were moderately suitable, whereas the pedons (3, 5 and 6) were marginally suitable due to severe erosion. Similarly, the lowland were marginally suitable due to severe erosion and fertility. Similarly, Satyavathi and Suryanarayan Reddy (2004) reported that Typic Haplustalfs in Telangana region were moderately suitable for growing groundnut as they exhibited similar limitations in soil fertility and physical characteristics.

Pearl millet: Rainfall, depth, texture, $CaCO_3$ showed considerable impact on yield of pearl millet in Alfisols or Vertisols. The upland (pedon 1) was moderately suitable, due to moderate limitation of slope, erosion and texture. The midland (pedon 3) was moderately suitable due to moderate limitations of drainage. Whereas, the midland pedons (pedon 2, 4, 5 and 6) were marginally suitable due to severe limitation of drainage. Similarly, lowland (pedon 7) was marginally suitable due to severe limitation of drainage.

Pigeonpea: As it is long duration crop with deep roots, the rainfall, texture and soil depth play important role in the crop selection. The upland (pedon 1) was marginally suitable, due to severe limitation of rainfall. The midland pedons (pedon 2, 3, 4, 5 and 6) were marginally suitable due to severe limitation of rainfall, erosion, pH and ESP. The lowland pedon (pedon 7) were marginally suitable due to severe limitation of rainfall, severe erosion and ESP.

Sunflower: It is a short duration crop with shallow roots. It is mainly grown in low rainfall black soils. The area represented by upland (pedon 1) was moderately suitable due to moderate limitations of slope, climate and erosion. The midland (pedon 3) was marginally suitable due to severe limitations of drainage and pH. Whereas, midland pedons 2, 4, 5 and 6 were not suitable because of very severe limitations of drainage and pH. Similarly, the lowland was not suitable (potentially suitable) owing to its poor drainage, severe erosion and pH.

Maize: In general maize requires free drainage, well aeration, deep soil (100 cm) and soil free of salinity and alkalinity. The area represented by upland pedon was moderately suitable due to moderate limitations of slope and texture. Whereas, the midland (pedon 2) was moderately suitable due to moderate limitations of drainage and organic carbon content. The other pedons in the midland were marginally suitable due to severe limitations of pH and organic carbon content. Except midland (pedon3) which was not suitable due to very severe limitation of pH. Similarly, lowland pedon was not suitable due to limitation of pH.

Groundnut: It requires less depth and rainfall compared to other deep rooted crops. The upland were moderately suitable for crop owing to their moderate limitations of slope, erosion and lowland were not suitable (but potentially suitable) because of poor drainage. Whereas, midland pedons (pedon 2, 4, 5 and 6) and were not suitable attributed to very severe limitations of drainage and pH. Whereas, midland (pedon 3) was marginally suitable due to moderate limitations of drainage and pH.

The study reveals that there is a close relationship between physiography and soils. The formation of the diverse group of soils can be attributed to the variation in topography, causing erosion, leaching, sedimentation and other pedogenic process modified by water table.

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